Multi-Area Security Constrained Economic Dispatch

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Overview

- **Key Concepts**

- **Real Time Coordination**

- **Security Constrained Economic Dispatch**

- **Formulation**

Key Concepts

- **Multi-Area Joint Dispatch**
  - *Achieve least cost solution by economically re-dispatching resources within multiple areas to*
    - Control parallel flows
    - Manage constraints

Key Concepts

- **Reduces Congestion**
  - *Expands pool of resources that are capable of addressing a region's transmission constraints*
  - *Provides better price convergence at the borders as a collective set of resources are used to solve system constraints*

- **Reduces Overall Cost of Congestion**
  - *Provides an RTO with the ability to request generation re-dispatch from neighboring market(s)*
  - *Solves internal constraints at a lower cost*

Real Time Coordination

- **Network Model**
  - *Each area must have sufficient network detail of neighboring area to determine accurate power flows*
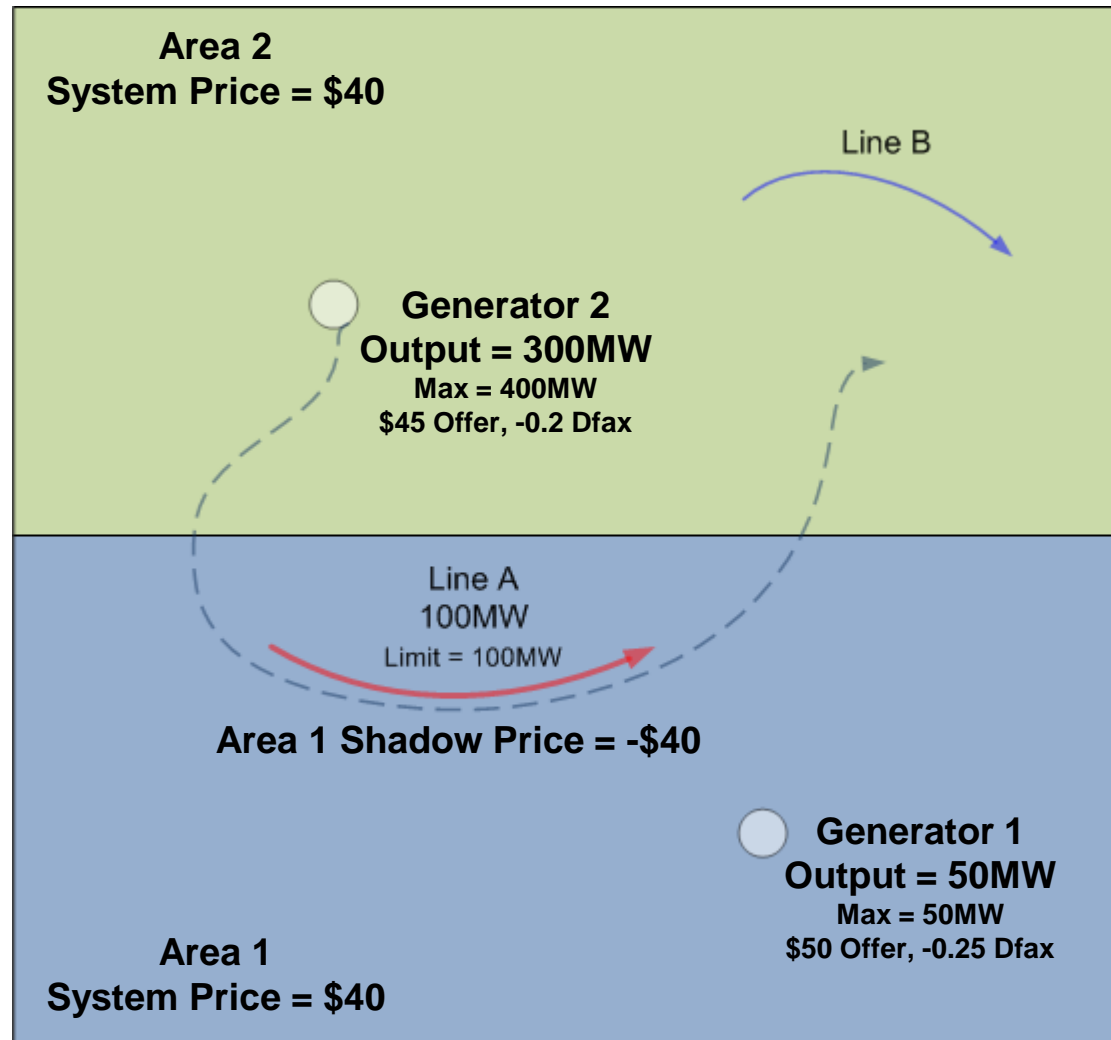
- **Automatic Data Exchange**
  - *Relief Request MW*
  - *Constraint Shadow Cost ($)*

- **Optimization**
  - *Area 1 and Area 2 re-dispatch systems to jointly solve for a system constraint until it is no longer active*

Real Time Coordination Example

Area 2
System Price = $40

Line B

Generator 2
Output = 300MW
Max = 400MW
$45 Offer, -0.2 Dfax

Line A
100MW
Limit = 100MW

Area 1 Shadow Price = -$40

Generator 1
Output = 50MW
Max = 50MW
$50 Offer, -0.25 Dfax

Area 1
System Price = $40

Area 1 requests 10 MW of relief at the current shadow price of -$40.

Area 2
System Price = $40

Line B

Generator 2
Output = 250MW
Max = 400MW
$45 Offer, -0.2 Dfax

Area 2 Shadow Price = -$25

Line A
90MW

Limit = 100MW

Area 1 Shadow Price = -$40

Generator 1
Output = 50MW
Max = 50MW
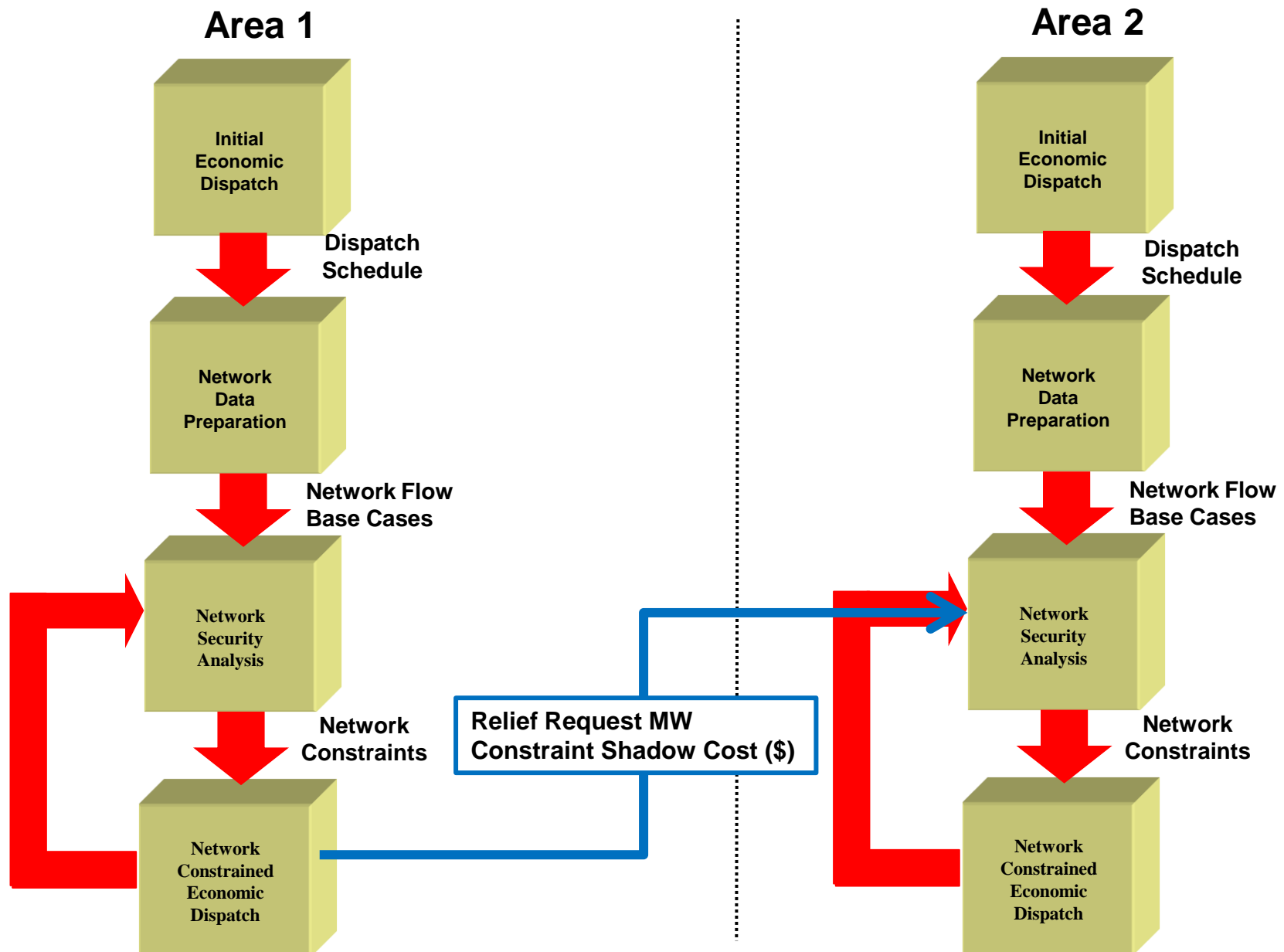**$50 Offer, -0.25 Dfax**

Area 1
System Price = $40
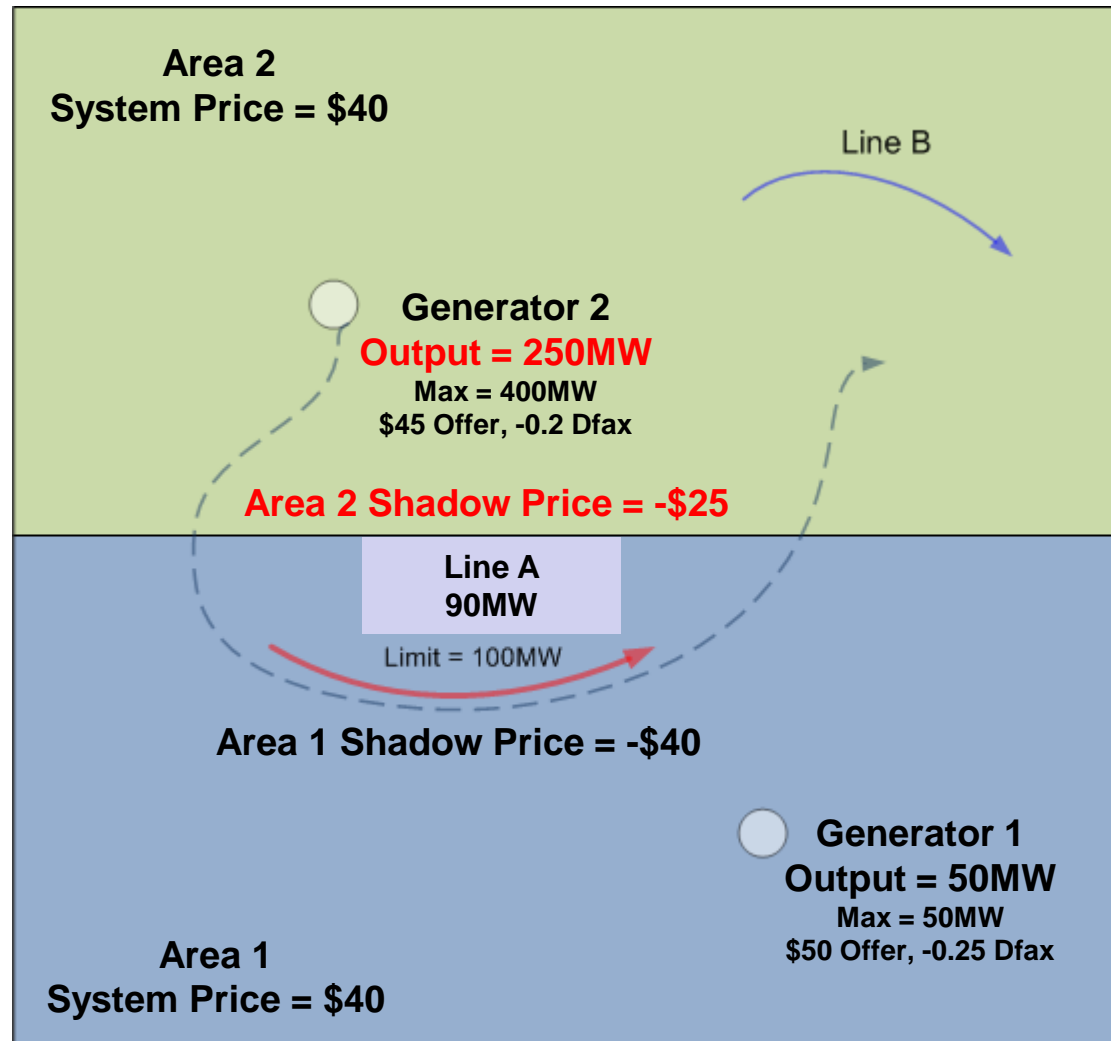
Generator 2 is reduced by 50 MW (to 250 MW) to provide 10 MW of relief.
Area 2 constraint shadow price is -$25.

Security Constrained Economic Dispatch

Security Constraint Economic Dispatch

•**Generator/Load/Reserve Requirements**
•**Initial generator status**

Initial Economic Dispatch

Dispatch Schedule

Network Data Preparation

Network Flow Base Cases

Network Security Analysis

Revised Dispatch Schedule

Network Constraints

Network Constrained Economic Dispatch

Initial Economic Dispatch
Produces Generator and Load schedules based on Generator/Load/Reserve Requirements

Network Data Preparation
Develops hourly, un-solved power flows based on the commitment and generation schedule from the Initial Economic Dispatch and network data

Network Security Analysis
Generates network constraints if line (or interface) limits are not satisfied for the input schedule

Network Constrained Economic Dispatch
Redispatch Generation and Load to solve for Generator/Load/Reserve Requirements, network constraints

Data for Joint Dispatch
Relief Request MW =
MW Flow$_{\text{First NSA}}$ - MW Flow$_{\text{Last NSA}}$

Constraint Shadow Cost ($)

Multi-Area SCED

Area 1

Initial Economic Dispatch

↓ **Dispatch Schedule**

Network Data Preparation

↓ **Network Flow Base Cases**

Network Security Analysis

↓ **Network Constraints**

Network Constrained Economic Dispatch

Area 2

Initial Economic Dispatch

↓ **Dispatch Schedule**

Network Data Preparation

↓ **Network Flow Base Cases**

Network Security Analysis

↓ **Network Constraints**

Network Constrained Economic Dispatch

Relief Request MW Constraint Shadow Cost ($)

Multi-Area SCED - Optimization

- **Transmission Demand Curve (TDC) is used by Area 2 to solve for Area 1 internal constraint**

    - *Model Relief Request MW amount and Constraint Shadow Cost for minimization of dispatch costs to solve for external constraint*

    - *Prevents Area 2 from dispatching system at a higher cost than Area 1*

Multi-Area SCED - Formulation

$$\underset{\{g_i\}}{Min} \sum_{i \in A_1} C_i(g_i) + \sum_{k \in A_2} \lambda_k p_k$$

S.T.

$$\sum_{i \in A_1} g_i - \sum_{j \in A_1} D_j = 0$$

$$\sum_{i \in A_1} S_{k,i} g_i' \le f_{pre,k}^{\max} - f_{pre,k} + \sum_{i \in A_1} S_{k,i} g_i$$

$$\forall k; k \in A_1$$

$$\sum_{i \in A1} S_{k,i} g_i' - p_k \le \mathrm{Re}\, l_k + \sum_{i \in A1} S_{k,i} g_i$$

$$\forall k; k \in A_2$$

$$p_k \ge 0 \;\; \forall k; k \in A_2$$

$$\lambda_k$$

$$\mathrm{Re}\, l_k$$

$$k \in A_2$$

⬅

$$k \in A_1$$

➡

$$\underset{\{g_i\}}{Min} \sum_{i \in A_2} C_i(g_i) + \sum_{k \in A_1} \lambda_k p_k$$

S.T.

$$\sum_{i \in A_2} g_i - \sum_{j \in A_2} D_j = 0$$

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$$\sum_{i \in A_1} S_{k,i} g_i' - p_k \le \mathrm{Re}\, l_k + \sum_{i \in A_1} S_{k,i} g_i$$

$$\forall k; k \in A_1$$

$$p_k \ge 0 \;\; \forall k; k \in A_1$$

Multi-Area SCED Advantages:

- *Economically re-dispatch resources within multiple areas to achieve least cost solution*
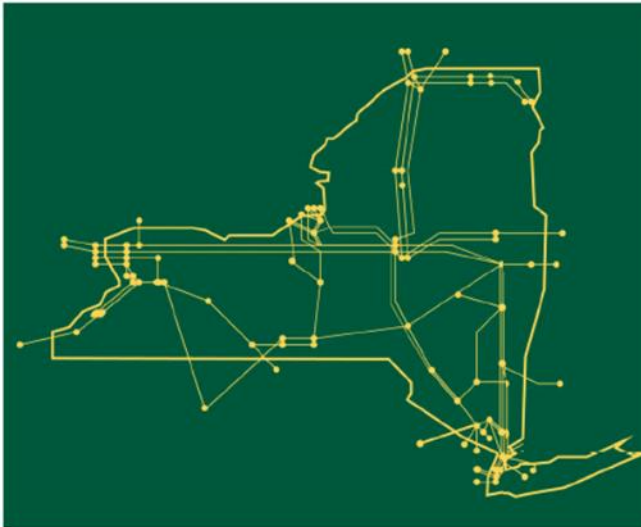- *Provide consistent pricing profile across multiple areas*

Additional Multi-Area SCED Opportunities:

- *PAR coordination between two areas to relieve system constraints*

Potential Research Area:

- *Decentralized economic dispatch for distributed generation*

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